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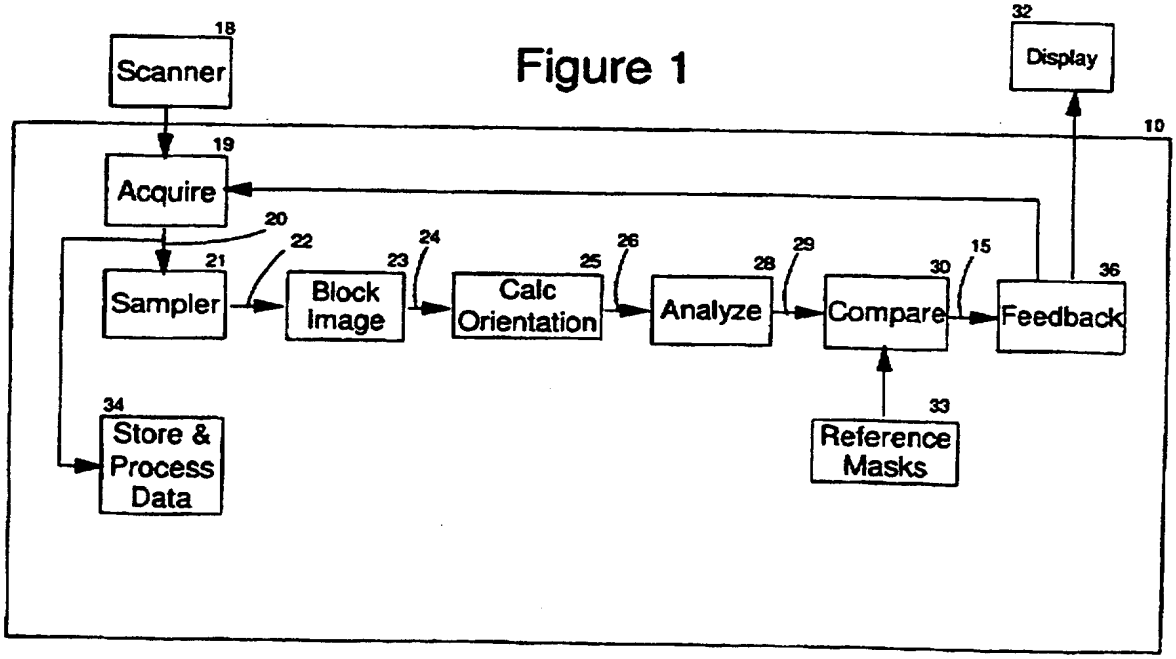
(54) Abstract Title
Apparatus for capturing a fingerprint

(57) Determining modules (21, 23, 25, 28 and 30), are responsive to acquisition of fingerprint image data to determine a core position (15) of the fingerprint. A feedback module (36) is co-operable with a display (32) to prompt the user to adjust the placement of the finger on the scanner (18) according to any difference between the determined core position and a required core position. A storage module (34) stores the fingerprint image data before further processing.

Figure 1



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A METHOD AND APPARATUS FOR CAPTURING A FINGERPRINT

The present invention relates to a method and apparatus for capturing a fingerprint.

A fingerprint is a copy of a pattern of ridges and valleys present on the fleshy pad on the end portion of a person's fingers and thumbs. A scanner is commonly used to capture fingerprint images. The scanner can be a live scan device, where the person presses the finger onto a glass plate and the image is captured in real-time by a video camera within the scanner. The image is then transferred to computer memory where it is held as a 2-dimensional array of values representing pixel grey levels. Typically the image is 8-bit, that is, one byte represents one picture element, or pixel, and usually 0 represents black and 255 represents white.

Fingerprint images can be viewed on a computer display, printed by a hard-copy printing device and stored on magnetic or other storage media. Automatic processing of fingerprint images by computer is also desirable. For example, ridge-endings and ridge-splits (bifurcations) are unique properties of a persons finger, so identifying and storing these features in a computer database is desirable in order to discover, or confirm, the identity of the person at a later time.

It is important, when capturing a fingerprint image, that the correct part of a person's finger is placed on the scanner's glass plate. That is, the same part of the finger must be captured each time the person's identity is sought, otherwise the computer may not find matching data for the person within its database. One means of capturing the same portion of the finger is to ensure that a fingerprint core is approximately in the middle of the image. The core of a fingerprint is a term commonly used within the fingerprint community, and is roughly described as the centre of the ridge-flow pattern disruption.

Provided the computer is able to display the fingerprint captured by the scanning device on its display, a trained human can locate the core in a fingerprint image, and can move the finger on the scanner's glass window so that the core is positioned near the centre of the image. However, a fingerprint scanner is likely to be used by people who do not know what the core of a fingerprint is, nor why it should be positioned in the centre of the fingerprint image, so there is a requirement for a

computer to direct the user of the scanner to move their finger to the correct position.

For this to be achieved, the computer must be able to locate the position of the core of a fingerprint, and then indicate to the user of the scanner in which direction to move the finger.

Accordingly, the present invention provides an apparatus for capturing a fingerprint from a user, said apparatus comprising: acquisition means adapted to acquire fingerprint image data; determining means, responsive to acquisition of said fingerprint image data, to determine a core position of said fingerprint from said fingerprint image data; feedback means co-operable with a display and responsive to determination of said core position to prompt said user to adjust the placement of said finger on said scanner according to any difference between said determined core position and a required core position; and storage means, responsive to said determined core position being proximate said required core position, to store said fingerprint image data.

In a further aspect, the invention provides a method for capturing a fingerprint from a user as claimed in claim 13.

Embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 shows an apparatus for capturing a fingerprint according to the present invention;

Figure 2 shows a scheme for numbering ridge flow orientation;

Figure 3 shows a set of fingerprint ridges and a pixel orientation mask;

Figure 4 shows a set of arrows for indicating finger movement required to locate a fingerprint core according to an embodiment of the invention; and

Figure 5 shows a user interface for indicating finger movement required to locate a fingerprint core according to another embodiment of the invention.

The present invention includes a computer 10 having a number of software modules 21, 23, 25, 28 and 30 operable to calculate in real-time an orientation map 26 of a fingerprint and then analyze the orientation map to determine a core position 15 for the fingerprint.

An orientation map 26 is a 2-dimensional array of data, where each element represents one block, say 16 x 16 pixels, of a fingerprint image. The data in the orientation map represents the angle of ridge flow, quantized to a suitable resolution, within each block of the fingerprint image. Figure 2 shows a scheme for numbering the ridge flow orientation, quantized to 8 directions. Here an orientation map value of 1 represents horizontal ridge flow, a value 2 represents the direction 22.5 degrees anticlockwise from direction 1, and so on. The orientation map 26 can be calculated by various means, the scheme implemented in present embodiment is described in a paper by B. M. Mehtre called "Fingerprint Image Analysis for Automatic Identification" in Machine Vision and Applications, vol. 6, pp. 124-139, published by Springer-Verlag 1993.

In an embodiment of this scheme, Figure 1, image data is fed from a scanner 18 to the computer 10. The image data is acquired by a module 19 which provides an initially sampled array 20 of fingerprint data. The data 20 is fed through a sampler module 21 which, by averaging sub-samples, reduces the initially sampled array 20 to an array 22 of 256 x 256 pixels. This reduces the amount of image data, and so increases the speed of processing in the following modules. The reduced array 22 of image data is then logically split into 2-dimensional blocks 24, 8 x 8 pixels in size, by a blocking module 23.

For each pixel 30 within each block 24, a dominant ridge orientation is calculated by an orientation module 25 by examining the grey scale values along the 8 directions of Figure 2. As shown in Figure 3, for a pixel 39, the variation of sampled grey scale values will be relatively large in any direction traversing the ridge orientation, in this case direction 1, and smallest in the direction of the ridges 31. By choosing the direction of smallest variation, the ridge orientation can be determined at each pixel 39 within a block. Then, a histogram (not shown) of the number of pixels within the block having an orientation direction 1 through 8 is calculated, and the overall block orientation is the peak direction in the histogram, provided it exceeds some threshold.

In areas of the fingerprint image where there is no ridge pattern, because the area was not covered by the finger or because the image data is poor quality, the threshold will not be met and so the block is said to have no orientation, such blocks are referred to hereafter as a background blocks.

Once the orientation map 26 has been calculated in this manner, it can be analyzed by modules 28 and 30 to discover the location of the fingerprint core. The analysis module 28 begins by searching the orientation map for blocks with horizontal, or near horizontal, orientation. The module 28 then looks at a core candidate area of size 7 x 7 blocks around each of these blocks and, if the surrounding blocks don't contain any background blocks, the area is deemed a core candidate area 29 to be sent for further processing. It will be seen that because an area of 7 x 7 blocks is chosen, blocks within 4 blocks of the edge of the orientation map 26 need not be proposed as core candidates, thus reducing the further processing required.

Each of the proposed core candidate areas 29 are then further processed by a module 30 to compare them with reference masks 33 that represent four orientation patterns that are commonly found in fingerprints. These are typical of the classification types: right loop, left loop, arch and whorl, terms which are commonly used within the fingerprint community. The core candidate areas 29 are scored according to how closely they match each of the four reference orientation masks 33. The maximum score indicates the core candidate area 29 that most closely matches one of the masks, and the core position 15 is determined to be at the centre of the "winning" core candidate area.

It will be seen that an untrained or uncooperative user can place their finger with its core away from the centre of the fingerprint image. The present invention provides user with feedback, so that they may adjust their finger placement, before their fingerprint image data is finally acquired and stored. This avoids large amounts of unnecessary processing before discovering that poor image data has been acquired.

One manner of providing feedback is to display text directions on a computer display 32. These can, for example, be instructions like "move your finger left" or "roll your finger down a little", to ensure that an image of the correct portion of the finger is acquired. In this embodiment, a feedback module 36, which is fed with the determined core

position 15 and a required core position, continually gives the person instructions of this type until the finger is in the correct position, at which time a module 34 captures and store the image data 20. It will be seen that because of the efficiency of determining the core position 15 described above, feedback can be given quickly enough to be useful to a user trying to learn how to place their finger correctly on the scanner 18.

Text feedback, however, assumes that the person using the scanner can read and fully understand the instructions appearing on the computer display 32, even after the instructions have been translated to the preferred language of the user.

In another embodiment of the invention, Figure 4, a graphical feedback module 36 displays graphical icons 40 to 47, shaped according to the exact instructions to be transmitted to the user, on top of a displayed fingerprint image on the display 32. In this embodiment, these icons are arrows representing instructions to "roll left" 40, "roll right" 41, "pivot anti-clockwise" 42, "pivot clockwise" 43, "move up" 44, "move right" 45, "move down" 46 and "move left" 47. The feedback module 36 colours the arrows when required to indicate or highlight a direction of movement to the user.

Because of the relative precision needed to locate the core position and to reduce the number of times a fingerprint image needs to be acquired and its core determined as above, it is desirable to provide a larger range of icons (not shown) incorporating intermediate instructions, for example, "move up and left", "move up and right", "move down and right" etc. Similarly, more than 2 roll arrows can be provided. The full range of arrow icons can, however, be confusing and difficult to interpret, for example, the user may be required to pivot their hand about an axis perpendicular to the plane of the scanner/finger, arrow 42 or 43. This is difficult to represent intuitively, particularly for a person using the scanner for the first time.

In another embodiment of the invention, the feedback module 36 employs a more intuitive means of directing the positioning of the finger, Figure 5. Here, the feedback module 36 displays an image of the fingerprint 12 overlaid by two circles 13, 14 of different sizes, one inside the other. The user is instructed to place their finger on the scanner glass window such that their fingerprint image covers the larger

of the circles 14. The module 36 then places a cross 15, or some other symbol, at the determined core position, calculated as described above. The user is then instructed to move their finger, and the feedback module 36 prompts the acquisition module 19 to acquire new fingerprint image data 20, until the cross 15 is positioned inside the smaller of the circles 13. With very little effort the user quickly learns how to move the finger to accomplish the desired result, provided the core position is constantly indicated by the position of the cross 15 as the finger is moved. This of course is possible because of the speed at which the core position is calculated as described above.

Once the cross 15 is located inside the circle 13, the module 34 takes the sampled image data 20 for this position and stores this data for further processing. This further processing is not relevant to the present invention, although it is sufficient to say that it is much more time consuming to repeat than the calculation of the core position 15 as described above, if the sampled image data 20 is found to lack a core position.

It will be seen that, for simplicity, the modules 21, 23, 25, 28, 30 and 36 have been described as operating in sequential order. It is possible, however, for the functions to be operated in parallel or alternatively nested within one another. Thus, one block of the image data 20 could be sub-sampled and its orientation calculated in one thread or process, while these operations are carried for other blocks by other processes or other threads within the same process. Similarly, the comparison module 30 could be testing core candidate areas, while the analysis module continues to search the orientation map for further candidates 29.

In any case, it will be seen that the present invention enables a person using the fingerprint scanner 18 to be directed where to position a finger on a scanner glass window in a clear and easy to understand manner, without lengthy explanation or training.

CLAIMS

1. An apparatus for capturing a fingerprint from a user, said apparatus comprising:

acquisition means adapted to acquire fingerprint image data;

determining means, responsive to acquisition of said fingerprint image data, to determine a core position of said fingerprint from said fingerprint image data;

feedback means co-operable with a display and responsive to determination of said core position to prompt said user to adjust the placement of said finger on said scanner according to any difference between said determined core position and a required core position; and

storage means, responsive to said determined core position being proximate said required core position, to store said fingerprint image data.

2. An apparatus as claimed in claim 1 wherein said feedback means graphically prompt said user to adjust the placement of said finger.

3. An apparatus as claimed in claim 2 wherein said feedback means comprises:

a set of graphical icons, each icon corresponding to an adjustment said user must make to reduce any difference between said determined core position and said required core position; and

means for selecting one of said icons according to said difference, and for displaying said icon on said display.

4. An apparatus as claimed in claim 3 wherein said set of graphical icons comprises a "roll left", a "roll right", a "pivot anti-clockwise", a "pivot clockwise", a "move up", a "move right", a "move down" and a "move left" icon.

5. An apparatus as claimed in claim 2 wherein said feedback means comprises means for displaying from said fingerprint image data, said fingerprint on said display.

6. An apparatus as claimed in claim 5 wherein said display means is adapted to display said required core position and said determined core position relative to said fingerprint display.

7. An apparatus as claimed in claim 6 wherein said display means is adapted to display said required core position as a circle and said determined core position as a cross.

8. An apparatus as claimed in claim 5 wherein said display means is adapted to display a required fingerprint position for said fingerprint relative to said fingerprint display.

9. An apparatus as claimed in claim 8 in which said display means is adapted to display said required fingerprint position as a circle.

10. An apparatus as claimed in claim 1 wherein said feedback means is adapted to prompt said acquisition means to acquire fingerprint image data in response to said determined core position being less than proximate said required core position.

11. An apparatus as claimed in claim 10 wherein said acquisition means is responsive to a user's finger being placed on a scanner to acquire said fingerprint image data.

12. An apparatus as claimed in claim 1 wherein said determining means comprises:

means for splitting said fingerprint image data into a plurality of blocks;

means for calculating, for each block, a measure of the orientation of the ridge flow for each said block;

means for analyzing said blocks, according to said ridge flow orientation, to locate one or more core candidate blocks; and

means for comparing the or each core candidate block and a pre-determined number of blocks surrounding the or each core candidate with one or more reference masks to determine the core position.

13. A method for capturing a fingerprint from a user, said method comprising the steps of:

acquiring fingerprint image data;

responsive to acquisition of said fingerprint image data, determining a core position of said fingerprint from said fingerprint image data;

responsive to determination of said core position, prompting said user via a display to adjust the placement of said finger on said scanner according to any difference between said determined core position and a required core position; and

responsive to said determined core position being proximate said required core position, storing said fingerprint image data.

14. A method as claimed in claim 13 wherein said determining step comprises:

splitting said fingerprint image data into a plurality of blocks;

calculating, for each block, a measure of the orientation of the ridge flow for each said block;

analyzing said blocks, according to said ridge flow orientation, to locate one or more core candidate blocks; and

comparing the or each core candidate block and a pre-determined number of blocks surrounding the or each core candidate with one or more reference masks to determine the core position.

The Patent Office

10

Application No: GB 9724455.2
Claims searched: 1 to 14

Examiner: John Donaldson
Date of search: 3 February 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): G4R(REP, RHA, RPF)

Int Cl (Ed.6): A61B 5/00, 5/117; G06K 9/00; G07C 9/00

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 2267771 A	(CENTRAL RESEARCH), see abstract	-
A	US 5140642	(HSU), see abstract	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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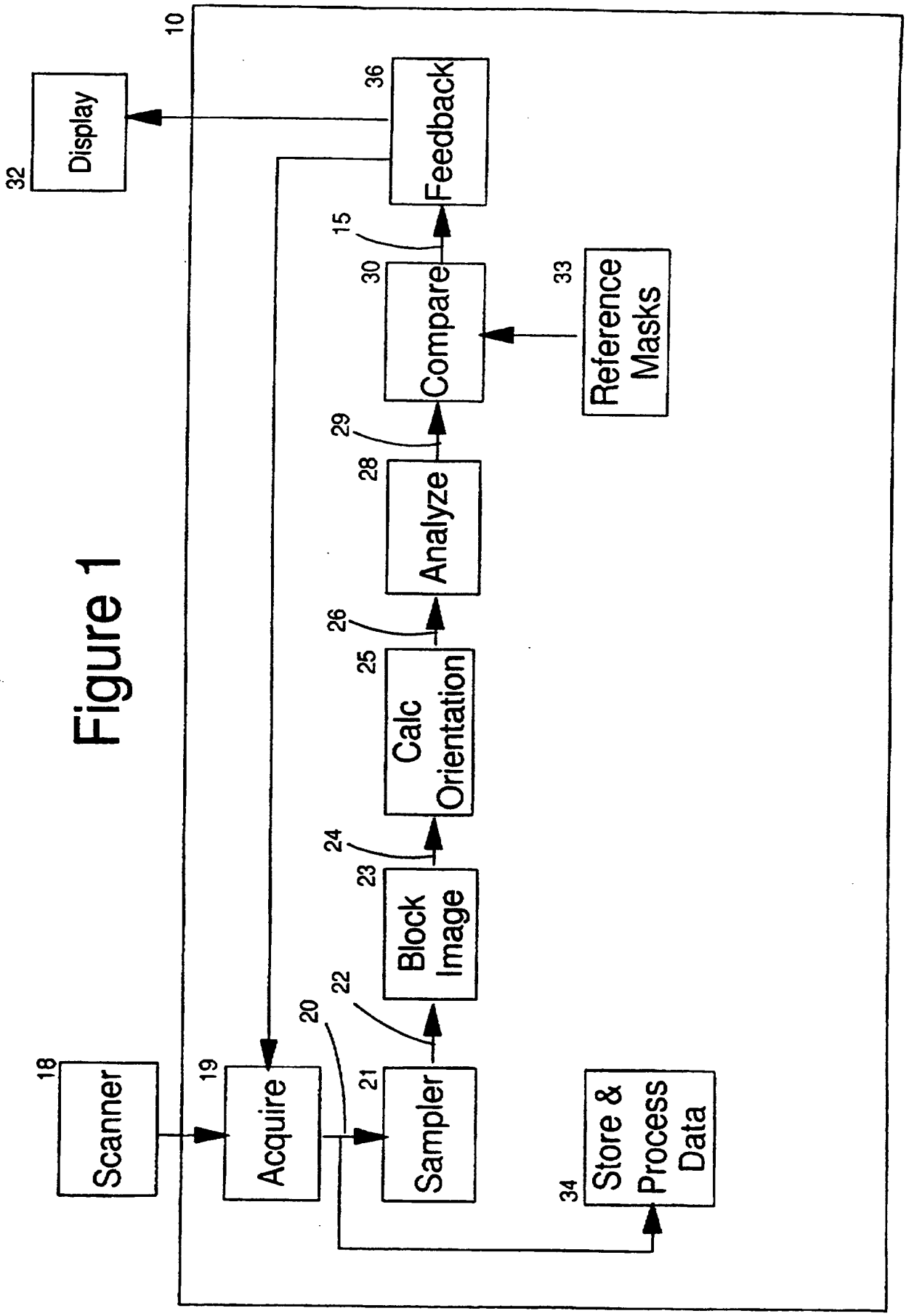

Figure 1

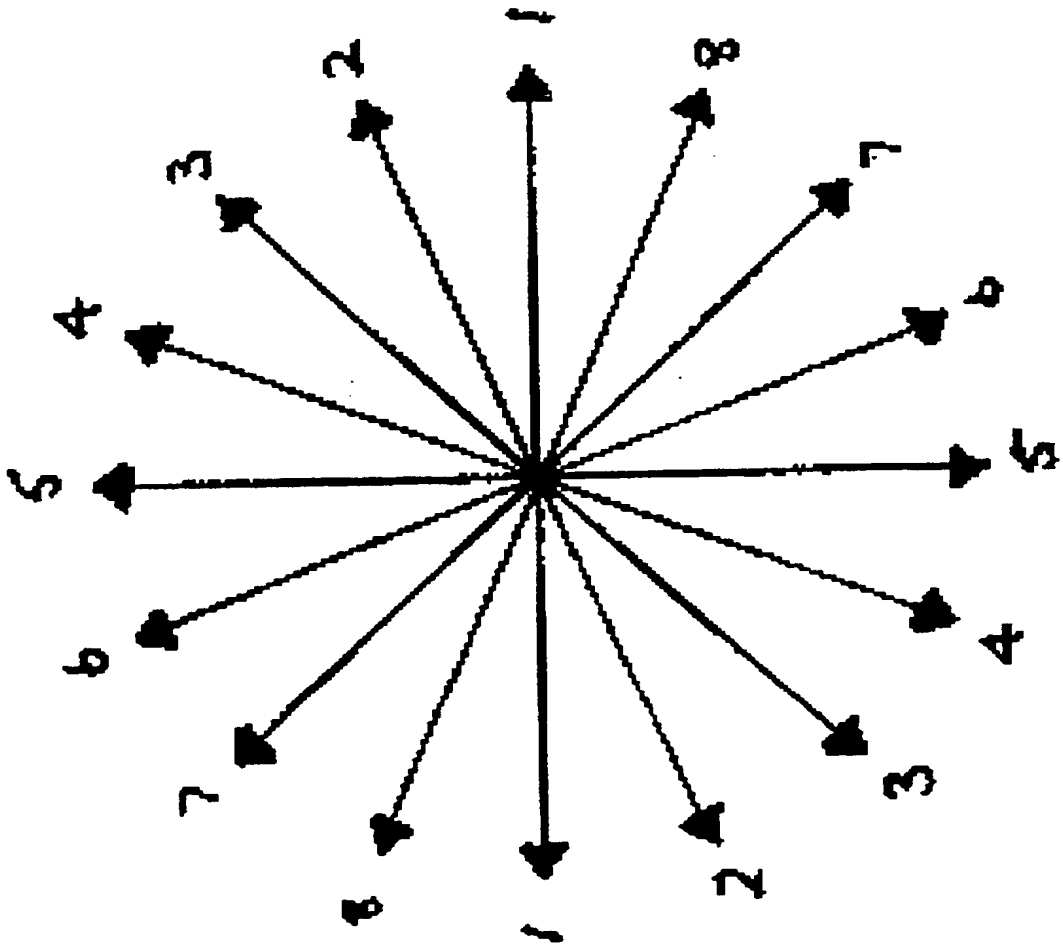

Figure 2

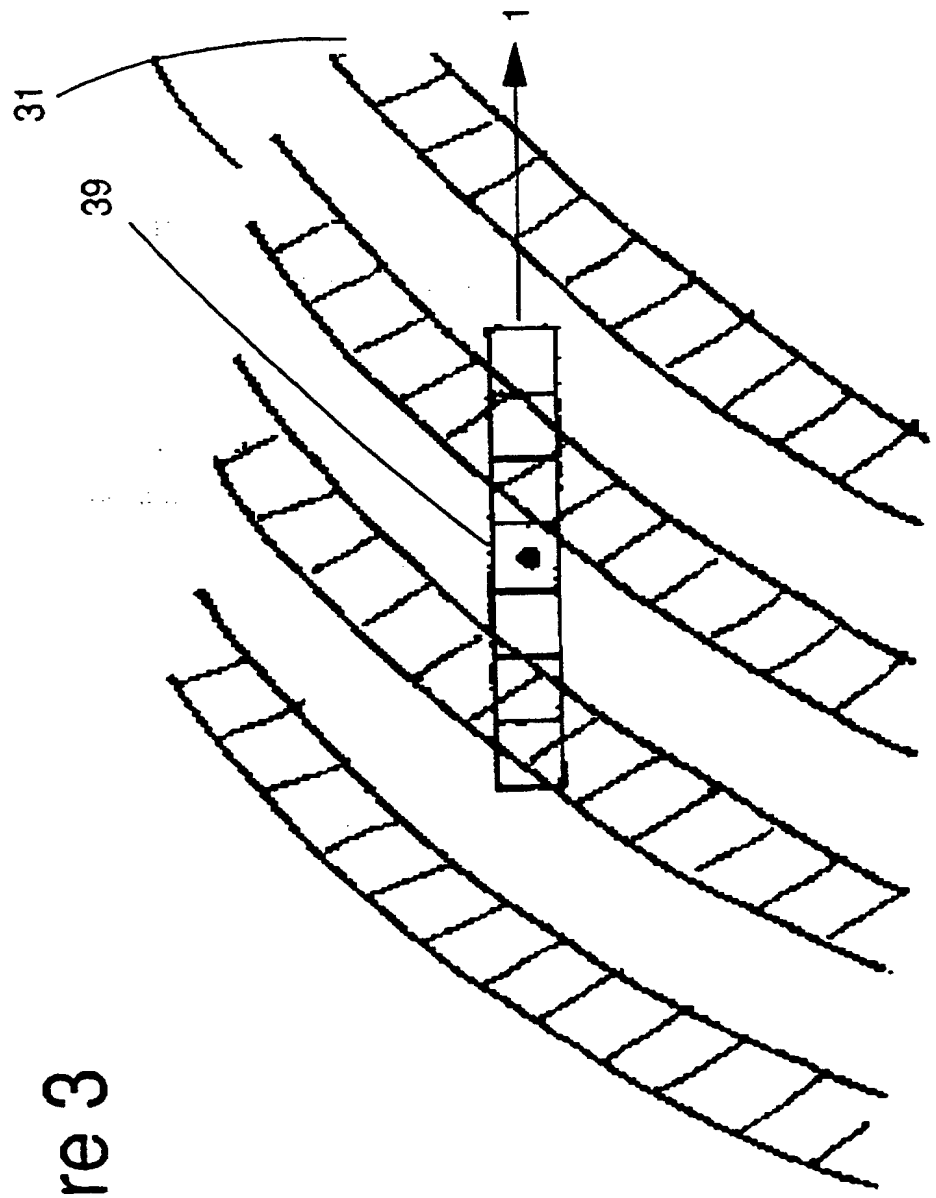

Figure 3

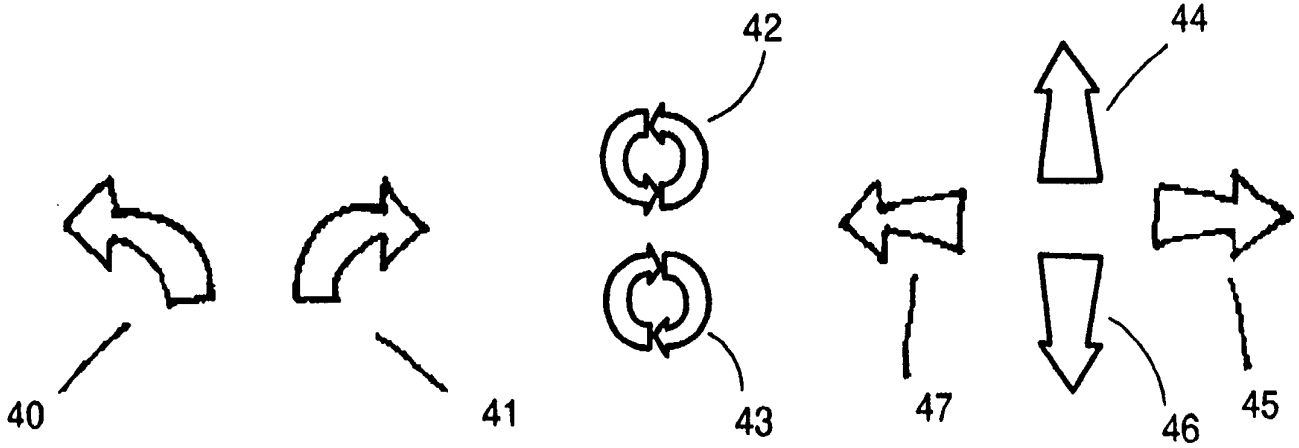

Figure 4

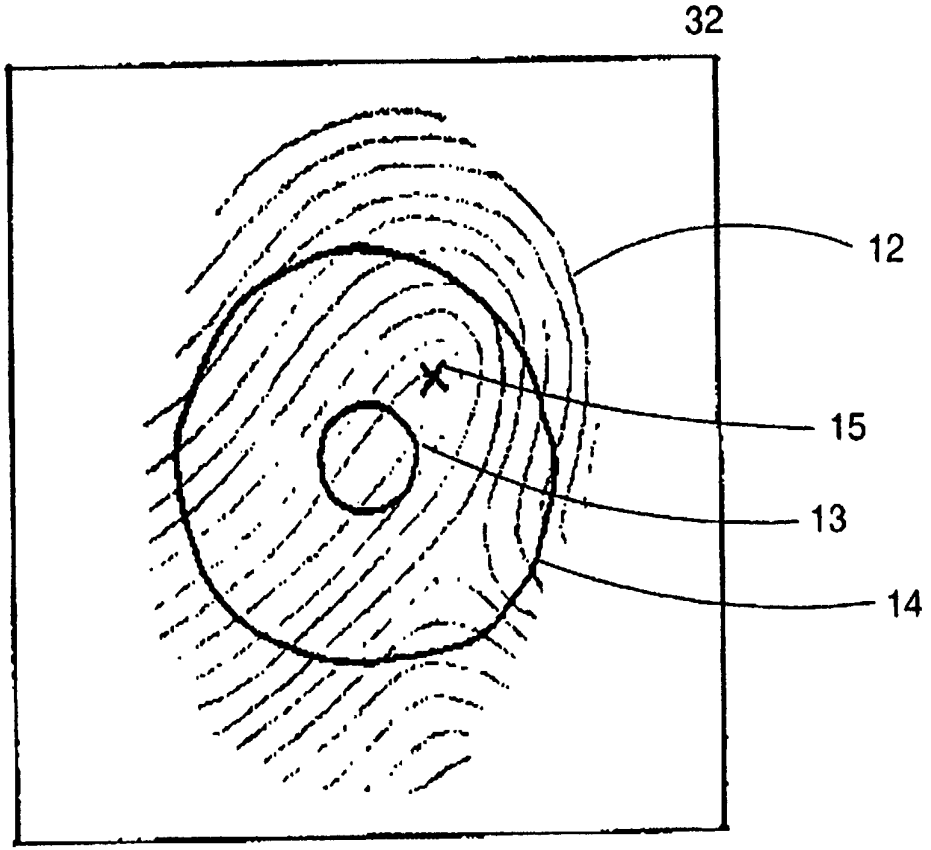

Figure 5